ology of cardiomyopathy, further research in this area will focus on detecting biochemical defects before deterioration of function occurs. Finally, in patients with Duchenne's muscular dystrophy, there is evidence of a localized myocardial metabolic abnormality that is unique to this disease and can be detected by PET. Again, FDG proved to be a sensitive marker of a regional shift in substrate metabolism.

Positron-emission tomography is still in its infancy, but these initial studies show the potential for metabolic imaging in cardiac disease, especially for such important clinical questions as defining tissue viability in patients with ischemic heart disease. Refining the technique will allow more accurate diagnosis of cardiac disease and better biochemical understanding of the underlying cause.

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New Developments in Contrast Media

RESEARCH OF CONTRAST MATERIAL has recently brought into focus a number of new developments that should have major impacts on the practice of radiology in the near future.

The first of these is the production and clinical testing of low-osmolality media. In general, these new substances take one of two forms: nonionic agents or monoacid dimeric agents. These substances differ from the current ionic media by a decrease in the osmotic pressure of the molecules for a given concentration of iodine. Thus, the new media have a ratio of iodine atom to dissolved particle of 3, whereas current media have a ratio of 1.5. Animal and clinical testing to date indicate that the low-osmolality media are both safer and more comfortable when used for arteriography. While the chemotoxicity of these media is substantially less than that of current media, the data on anaphylactoid effects are still incomplete. Preliminary findings, however, suggest that a significant improvement can be expected in this area also. Currently, only one nonionic agent (metrizamide) is approved for intravascular use in this country. Other nonionic agents are pending approval by the Food and Drug Administration and, when available, will probably become the agents of choice for arteriography. Because they are expected to be considerably more expensive than current ionic media, their overall role in vascular injections remains to be determined. Results of both studies on animals and clinical studies suggest that these media will also confer less toxicity in the subarachnoid space than metrizamide or iophendylate (Pantopaque).

The second development of note concerns the use of perfluorocarbons as contrast agents for ultrasonography. Nonbrominated perfluorocarbons are presently used in humans as oxygen-carrying blood expanders and these substances, when injected as emulsions in both the brominated and nonbrominated forms, appear to combine a low toxicity with effective uptake by reticuloendothelial cells and macrophages, resulting in increased echogenicity of the liver and spleen and experimentally induced tumor rims and myocardial infarcts. Preliminary trials in humans are currently under way and appear highly promising, particularly for enhanced visualization of liver tumors.

The third area of particular interest is the development of contrast agents for magnetic resonance (MR) imaging. Preliminary observations suggest that such agents will dramatically extend the diagnostic value of MR imaging, despite the inherent high-contrast differences obtainable for different tissues with this new technique. Conventional radiographic contrast media produce their effect by high-electron density that absorbs x-rays. MR imaging media, as currently conceived, function by altering local magnetic environments. These paramagnetic substances can be used for intravascular injection, subarachnoid installation or gastrointestinal tract opacification. Data on animals and preliminary data on humans suggest that these compounds can be used effectively in a fashion similar to that of conventional media with very low toxicity anticipated.

Each of these new developments should reach a stage of clinical use within one to three years, with the advent of the new nonionic media for conventional radiography expected within a year.

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Computed Tomography of the Spine

BECAUSE OF ITS ABILITY to show both soft tissue and bone abnormalities in excellent detail, high-resolution computed tomography (CT) has assumed a dominant role in imaging of the spine, particularly in the lumbar area. Its efficacy in evaluating degenerative disc disease, tumor, trauma, congenital abnormalities and infectious processes has been documented.

More than 95% of lumbar disc herniations occur between L-3 and S-1, so that by scanning these three levels most lumbar disc problems will be encompassed. Contiguous 4- to 5-mm thick axial scans are taken, with additional scans parallel to the discs obtained in some cases. Contiguous scans decrease the likelihood of missing herniated disc fragments that have migrated above or below the disc level and, in addition, make possible sagittal and coronal reformations that are useful in some cases. CT is more accurate than conventional myelography in diagnosing lumbar disc herniation because even lateral and L5-S1 herniations remote from the thecal sac can be readily seen. CT clearly shows central and foraminal spinal stenosis that often plays a significant role in low back syndromes. Abnormalities of the facet joints, which may contribute to low back pain, are also clearly shown. By showing whether root compression is due to focal herniation or bulging of the annulus and whether there is extruded disc material, selection of appropriate therapy such as surgical repair or enzyme injection can be aided. Evaluating the lumbar spine postoperatively with plain CT may be difficult because of surgical distortion. The use of intravenous contrast media in this situation can help distinguish between recurrent disc herniation and scarring.

The role of plain CT in evaluating cervical disc disease is more controversial. Although thin-section CT (1.5- to 2-mm slices) can demonstrate disc herniations and spondylotic changes, diagnostic accuracy is not as high as in the lumbosacral spine. Many authors advise using an intrathecal water-soluble contrast agent to improve the diagnostic accuracy of CT examination of a patient with cervical degenerative disc disease.

The major limitation of plain CT is its inability to show intradural pathologic processes such as tumors. Conventional myelography or CT with intrathecal water-soluble contrast material is indicated when an intradural abnormality is suspected.

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Radiation Risks in Diagnostic Radiology

THE RISKS OF HARMFUL GENETIC and somatic effects associated with the low doses (a few rads or less) of ionizing radiation received during diagnostic x-ray examinations are too small to be measured. The existence of deleterious effects from much higher doses is irrefutable. The major uncertainty in inferring low-dose risks from dose-effect data obtained at high doses is selecting the type of extrapolation to be used in continuing the dose-effect curve into the low-dose region. Estimates obtained from a no-threshold, straight-line extrapolation of high-dose dose-effect data in animals and, in some instances, humans, to low doses, will be used here. Such estimates are generally considered "worst case," in that alternative plausible extrapolation schemes lead to lower estimates of risk at low doses.

The genetic risk resides in radiation-induced mutations, generally considered deleterious, which can be passed on to future generations via reproduction. No deleterious genetic (or somatic) effect has ever been documented from natural background radiation. This suggests that if the genetically significant dose, estimated in 1970 to be 0.02 rad per capita per year, remains well below the background radiation dose of 0.1 rad per capita per year at sea level, any additional genetic consequences will neither differ in kind nor exceed in quantity those that have been experienced throughout human history. To obtain a numerical estimate is futile, but taking into account that the dose required to double the spontaneous mutation rate is generally assumed to be 20 to 200 rads, the genetic risk of ionizing radiation from diagnostic x-ray studies would appear to be small. Even so, prudence dictates the maximum possible reduction of human gonadal exposure from diagnostic x-ray studies. To this end, gonadal shielding should be used whenever possible during x-ray procedures on a potentially procreative person.

No direct evidence exists for an association between radiation exposure in utero and harm to an unborn child as a result of a diagnostic x-ray study of the lower abdomen or pelvis of a pregnant woman. However, indirect evidence suggests the possibility of radiogenic birth defects and childhood leukemia. The estimated hypothetical risk of an observable birth defect from a 1-rad in utero dose is 1 to 5 chances in 1,000, whereas the natural incidence rate of birth defects is 40 to 50 per 1,000 live births. Studies in animals indicate that the most critical period for inducing a deformity is during organogenesis, weeks 3 through 7 postconception in humans. Human in utero exposure at high doses from the atomic bomb explosions at Hiroshima and Nagasaki indicates weeks 8 through 15 postconception to be the most critical period for inducing mental retardation. Although not seen in these persons, an increased chance of childhood leukemia for an in utero dose of 1 to 2 rads, from a spontaneous incidence rate of 1 per 3,000 to 1 per 2,000, is suggested by some retrospective epidemiologic studies. These possible risks should be explained to a pregnant patient and documented in her record.

The major concern regarding postnatal exposure to diagnostic x-ray studies is carcinogenesis. The estimated hypothetical lifetime risk per study of cancer developing after a latent period of 10 to 25 years varies from a few chances in a million for a (0.05-rad) two-view chest examination to almost 100 chances in a million for a (3-rad) computed tomographic brain scan. These risks are modest compared with the lifetime risk of dying in an auto accident—1 in 100—or contracting cancer spontaneously—180 in 1,000. The most recent screen-film systems for mammography deliver a mean glandular tissue dose as low as 0.1 rad for a two-breast, two-view study, giving an estimated lifetime risk per study for breast cancer induction after a latent period of 10 to 25 years in a woman aged 40 years or older of no more than a few chances in a million, compared with a natural risk of 1 in 10. The hypothetical risk is down dramatically from a decade ago as a result of the great reduction in dose which fact supports routine screening by age 40 as suggested by the American College of Radiology and the American Cancer Society.

In conclusion, the risks from diagnostic x-ray studies are too small to be measured directly. Estimates of the hypothetical risks show them to be small compared with many risks encountered in day-to-day life in American society. Nonetheless, diagnostic x-radiation must be used prudently and every attempt made to obtain the desired diagnostic information with the minimum radiation dose.

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Neonatal Intracranial Ultrasonography

ULTRASONOGRAPHY OF THE NEONATAL BRAIN is a quick, noninvasive procedure that can be done on fragile neonates in an intensive care nursery without sedation. High-frequency sector-image ultrasound is used to examine the brain through open fontanelles and sutures.

Ultrasonography is most important for diagnosing intracranial hemorrhage due to the combination of immaturity of the germinal matrix that lines the ventricles and immaturity of the lungs and the autoregulatory system. This bleeding is the